

BOTANICAL GAZETTE

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The fructification of *Juniperus*.¹

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WITH PLATE XXXIII.

With rare exceptions most of the plants of our American flora ripen their fruit during the same season in which the blossoms are produced. Among ligneous plants in North America the only noted deviations from this rule of nature are found among the true pines, or genus *Pinus* as it is now limited and defined by most systematists, and in that section of the genus *Quercus* classified under *Melanobalanus* or black oaks.

These trees are monœcious and blossom in the spring or early summer, the young fruits being only partially or slightly developed at the end of the first season's growth and not ripening until the autumn of the second year. The sequoias of California are also said to be biennial fruited, and it has been stated that the cones of several species of *Pinus* require three seasons to arrive at maturity.

The witch hazel, *Hamamelis Virginiana* L., and the seaside alder, *Alnus maritima* Muhl., differ from these in only requiring one season of growth from the flower to the ripe fruit, for although the blossoming takes place in the autumn, the young ovary makes little or no growth before the following spring, and it becomes fully developed and ripe in the ensuing autumn when the plant is again in flower, so that just a year elapses between the time of flowering and the maturing of fruit; while among the black oaks and the pines, in this latitude, the time necessary for maturation approximates eight-ten months, or two summers and one winter.

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Except the pines and sequoias, all of our other coniferous trees are commonly credited with being annual fruited, although various authors have distinctly stated that the junipers or savins are biennial fruited.

Dr. Asa Gray in his manuals leaves us to infer that the junipers are annual fruited, and so do Emerson,² and Chapman.³

Bigelow⁴ says of the fruit of *Juniperus communis* that "it requires two years to arrive at maturity from the flower," but makes no observation as to *J. Virginiana*, so that it would be assumed to be annual fruited; and Wood⁵ makes the same record.

Watson⁶, in giving the characters of the genus *Juniperus*, states that the fruit only arrives at maturity in the second year, and Coulter⁷ makes a similar note.

Dr. George Engelmann in his monograph⁸ says: "The juicy strobil, galbulus, which we may for shortness' sake designate by the popular name of *berry*, matures like the fruit of the oaks and the true pines in the second year, but, unlike them, it attains almost its full size in the first autumn, when even the stony coating of the seed is pretty well formed; but it matures fully a year later. We often observe berries of both years, young and maturing ones, on the same stock; but where it bears only every other year, as conifers often do, fruit of one season and of one state of maturation only is found at one time."

So far as I have been able to examine into the subject, these instances are the only records by American writers where it is distinctly implied or stated that the fruit of *Juniperus* requires more than one season to arrive at maturity.

Quite a number of European authors record it as a peculiarity, although their testimony is conflicting. The point is not mentioned in some works which might be expected to refer to it.

Behlen⁹ says of *J. Sabina*, *J. communis*, *J. Oxycedrus*, *J.*

²Trees and Shrubs of Massachusetts.

³Flora of the Southern States.

⁴Medical Botany, III (1820).45; Fl. Bostoniensis, 1840, 399.

⁵Class Book of Botany, 663.

⁶Botany of California, II. 111, 112.

⁷Flora of the Rocky Mountain Region, 429.

⁸The American Junipers of the Section *Sabina*, Trans. Acad. Sci. St. Louis, III (1877). 586.

⁹Bot. Handbuch, 1824. 269-275.

Virginiana, and others, that the fruit is ripe in the second autumn; and Antoine in his monograph¹⁰ says that both the true junipers and those of the section *Sabina* take two years to mature fruit, while Carrière¹¹, in characterizing the genus, says the maturation is biennial, and in the description of our red cedar, *Juniperus Virginiana*, speaks of the fruit as ripening the second year.

Parlatore¹² says the galbulus ripens the second year. Nicholson¹³ says of the genus as a whole: "Fruit berry-like, ripening the second year."

Among those who mark a variation within the genus in time of ripening of fruit we find that Spach¹⁴ says that the maturation of the section *Oxycedrus* is biennial; of the section *Sabina* annual or biennial; and that the fruit of *J. Virginiana* ripens before the end of the same year after blossoming, but persists until the following spring.

Endlicher¹⁵ says that the galbuli mature in the first or only in the second year.

Loudon¹⁶ says of the berries of the common juniper, *Juniperus communis*, that "they continue on the bush two years;" and he further states¹⁷ that the berries of *Juniperus Phoenicea* are not ripe "till the end of two entire years." In his summary of the specific characters of the Red Cedar,¹⁸ *Juniperus Virginiana*, he says: "Flowering in May and ripening in October;" so that he evidently counted it, like most plants, as maturing in the same season that it blossomed.

Boissier¹⁹ divides the section *Sabina* into five annual and one biennial fruited species, but makes no comment as to the time required by the section *Oxycedrus* to mature fruit, four species of this section coming within the scope of his work.

In the course of my work at the Arnold Arboretum I have had occasion to specially notice *Juniperus communis* and *J. Virginiana* during the past three seasons, and the following

¹⁰Die Cupressineen-Gattungen: *Arceuthos, Juniperus und Sabina*, 1857, 9, 35.

¹¹Traité des Conifères, 1867, 8, 44.

¹²De Candolle's Prodrromus, xvi. 2 (1868). 475.

¹³Dictionary of Gardening, 1887, 211.

¹⁴Ann. des Sci. Natur. II. xvi (1841). 289, 292, 294.

¹⁵Genera Plantarum, Suppl. iv. 2. 2. Vienna, 1847.

¹⁶Arboretum et Fruticetum Britannicum, iv (1854). 2491.

¹⁷See p. 2501.

¹⁸See p. 2495.

¹⁹Flora Orientalis, v (1881). 708.

observations may serve to settle this point about the fructification in regard to the only three species which occur east of the Mississippi River. As a rule, they are dicæcious, but monœcious examples may sometimes be found.

As is well known, *Juniperus Virginiana* L. is one of the most widely distributed of our American trees, ranging in the east from the northern boundaries of the United States, to Florida, and westward to the Pacific coast.

In New England I find it is simply annual fruited, flowering about the latter part of April and maturing its fruit in the autumn of the same year. In examining specimens from other parts of the country, especially from the south, this characteristic of ripening in the same season seems to be constant. We find no green fruit on the plants in winter, and before spring the trees are often stripped of their ripe blue fruit by birds. The persistence of the fruit during winter and even through the following spring may have given rise to the impression that it was biennial. The galbulus is usually somewhat irregular, normally contains two seeds, and is composed of about three pairs of coalescing scales.

I have not been able to study living plants of *Juniperus Sabina*, var. *procumbens* Pursh., the only other eastern American species of the section Sabina; but, through the courtesy of correspondents, I have had fresh specimens at different stages. This species proves to be very distinctly biennial fruited, the large galbuli and the seeds ripening in the autumn of the second year. The galbulus, formed by the consolidation of six fleshy scales, in three pair alternately arranged, is usually more or less irregular instead of being perfectly round, and in the first season it attains three-fourths or four-fifths of its ultimate size.

The third and last of our eastern American species is the low-growing common juniper, *Juniperus communis* L., belonging to the section Oxycedrus, having three leaves in a whorl, and a native of the old world as well as the new. Very naturally, it has been much studied and monographed, and yet an important peculiarity of its fructification seems to have escaped notice. Instead of requiring only one year, as does *Juniperus Virginiana*, or two years, as is the case with *Juniperus Sabina*, var. *procumbens*, the fruit of *Juniperus communis* does not mature until the autumn of the third year after blossoming.

In the region about Boston this species generally blossoms from about the middle to near the end of May, or just about a month later than *Juniperus Virginiana*. The flowers appear in the axils of the leaves from well developed buds on the twigs of the previous season's growth.

The male flower, or catkin as it is sometimes called, is composed of five or six whorls of scales, three in each whorl, each scale usually bearing three or four anthers filled with globular slightly roughened pollen grains about one-fortieth of a millimeter in diameter.

The female flowers consist of three fleshy, tubular, pistil-like terminal organs, commonly considered as ovules, but whose position suggests scales, and by which term I shall provisionally refer to them. Outside of these and alternate with them are three obtuse, very short, thin, fleshy scales not noticeable at flowering time, and with the lower parts of their edges joined together and their inner surfaces connected near the base with the seed bearing scales. These are surrounded and protected by five or six whorls of pointed imbricated scales in alternate series of three like the leaves. When stripped of these outer scales the six inner ones, which ultimately form the seed and fruit, are hardly more than a millimeter in length; or, including the scaly covering, the whole length is nearly two millimeters. The upper ends of the three terminal fructiferous or seed bearing scales protrude beyond their scaly covering like three hollow pistils—they are called styles by Baillon²⁰ and some others—and diverge slightly outward from each other.

From each orifice there is exuded, when in perfect condition for fertilization, a minute globule of clear shining liquid which rests like an iridescent bubble on the tip and serves to catch the pollen and conduct it to the nucellus or ovule within.

After fertilization the tips of the tubular fructiferous scales seem less prominently exerted and except by a thickening around the base, no apparent growth takes place during the entire summer, so that by autumn or winter the little galbules are still not much more than a millimeter long. In this condition they look like buds and probably have usually been mistaken for such.

During warm days early in the following month of May, in the climate of Boston, an appreciable increase in size is ap-

²⁰Histoire des Plantes, XII (1892). 8.

parent, and a little later, or when the plants are again in good bloom, the year-old galbuli have grown to about four millimeters in length and nearly as large in diameter, the three fleshy enveloping scales having grown rapidly and become almost perfectly coalesced or consolidated around and above the three inner or seed-bearing scales, the outer protecting minute imbricated dry scales making no growth and being shoved aside and left at the base.

Growth and development are continued throughout this second summer and by the end of the second autumn the galbuli have attained to three-fourths or four-fifths of the ultimate size, and are still quite green without and within. The seeds are filled with soft milky immature albumen.

In the third spring and summer the albumen grows firm and solid, the process of hardening being gradual from the center toward the circumference, the differentiation taking place being quite plainly seen on making a cross section of the seed at the end of May or early in June. About the end of summer the fruits or galbuli begin to change color and assume the bluish or bluish-black color characteristic of maturity. The outer fleshy portion of the fruit changes from a green and hard texture to a soft mealy one, having a somewhat resinous sweet flavor. It is now, in the autumn of the third year from flowering, fully ripe and in a condition to germinate or be eaten by birds.

When not properly fertilized, or when otherwise imperfect or injured, the immature fruits often turn purplish and shrivel in the second season.

Some of the published figures of the fruit of *Juniperus communis* show the tips of more than three scales as forming the outer fleshy covering, another whorl of scales being represented with the tips showing around the sides of the galbulus. In fact, there are only three scales which combine to form the entire outer part of the fruit in this species; and at maturity their tips have become smooth and rounded, and of course are only to be noticed around the top or crown, leaving the sides perfectly smooth to the base. These scales at flowering time were not noticeable, being hidden, as already stated, beneath the outer leafy protecting scales.

I have not had enough or sufficiently fresh material to secure accurate data as to the length of time required to mature fruit among western species of *Juniperus* and those from

the Old World. Of course it is to be expected that *Juniperus communis*, which is indigenous in both Europe and Asia as well as North America, requires the same time to mature fruit in all regions. *Juniperus rigida* Sieb. & Zucc., of Japan, apparently also passes three seasons before arriving at maturity; but it seems hardly likely that all the species usually classed in this section, *Oxycedrus*, take so long before reaching full development. In the genus as a whole, probably a large proportion of the species ripen their fruits at the end of the second season; and there are others, besides *Juniperus Virginiana*, which mature their fruit in the same year in which they blossom.

It is almost impossible to determine these points with accuracy from ordinary herbarium specimens as they are generally collected, and, in making a study of the length of time required by the fruit of different species to arrive at maturity, herbarium material should be collected with special regard to this character; or, still better, the living plants should be carefully observed whenever possible.

For the accompanying plate and other assistance I am indebted to Mr. C. E. Faxon.

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EXPLANATION OF PLATE XXXIII.—Fructification of *Juniperus communis* L.
 Fig. 1. Male branch with flowers. Fig. 2. Female branch, flowers and fruit. *a.* Flowers. *b.* Fruit, one year old. *c.* Fruit, two years old (May 25), not mature until autumn. Fig. 3. Male flower, enlarged. Fig. 4. Scale of male flower, exterior view enlarged. Fig. 5. Scale of male flower, interior view, enlarged. Fig. 6. Female flower, enlarged. Fig. 7. Fruit one year after flowering, transversely divided, enlarged. Fig. 8. Fruit two years after flowering, transverse section, enlarged. Fig. 9. Seed, two years from flowering, showing resin glands on the back, enlarged.

Development of the embryo-sac in *Acer rubrum*.

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WITH PLATE XXXIV.

A study of the development of the embryo-sac of *Acer rubrum* L. presents in itself nothing new or striking, but from the standpoint of comparative morphology it is not wholly without interest. This work represents only a part of a series of similar investigations to be made upon various angiosperms of both related and widely separated families.